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20 JAN 2003

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1.	Your reference	LB1671
2.	Patent application number *(The Patent Office will fill in this part)*	0301236.6
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	Pursuit Dynamics plc Unit 1, Anglian Business Park Orchard Road Royston Hertfordshire SG8 5TW
	Patents ADP number *(if you know it)*	8333072002
	If the applicant is a corporate body, give the country/state of its incorporation	
4.	Title of the invention	Fluid Mover
5.	Name of your agent *(if you have one)*	Barker Brettell
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	10-12 Priests Bridge LONDON SW15 5JE
	Patents ADP number *(if you know it)*	7442494003

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of Filing *(day/month/year)*
GB	0223572.9	11/10/02
GB	0227053.6	20/11/02

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day/month/year)*

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11. I/We request the grant of a patent on the basis of this application.

Signature Barker Brettell Date

Barker Brettell 20/01/03

12. Name and daytime telephone number of person to contact in the United Kingdom — Lance Butler — Tel: 020 8392 2234

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FLUID MOVER

This invention relates to a fluid mover.

The present invention has reference to a fluid mover having a number of practical applications of diverse nature ranging from marine propulsion systems to pumping applications for moving and/or mixing fluids of the same or different characteristics. The present invention also has relevance in the fields of heating, cleaning, aeration, gas fluidisation and agitation of fluids and fluids/solids mixtures.

More particularly the invention is concerned with the provision of a fluid mover having essentially no moving parts.

Ejectors are well known in the art for moving fluids by the use of a steam jet emitted into a duct in order to move fluids through or out of appropriate ducting or into or through another body of fluid. The ejector principally operates on the basis of inducing flow by creating negative pressure, generally by the use of the venturi principle. Conventionally, the induced fluid generally enters the duct orthogonally to the axis of the jet, although there are exceptions where the reverse arrangement is provided.

USP 2 396 290 to *Schwarz* discloses a sludge system intended essentially as an apparatus for removing from storage tanks the accumulation of viscous tar or semi-fluid tar, oil sludges and the like. The *Schwarz* system has a throat body provided with an outwardly flared portion at one end, a steam intake nozzle extending into the body and having a central opening for the passage of material therethrough into the throat body, and a steam discharge nozzle at the flared end for drawing material out of the flared portion of the throat body. The principal objective of *Schwarz* is

to provide a means whereby the difficult materials recited above may be fluidised by a combination of the impact of the steam initially at the intake end of the throat body and the heat of the steam, the material being further subjected to the same action afforded by the discharge nozzle. The viscosity of the difficult material is thus reduced to improve flowability to allow pumping. It is to be noted that the flow of material whilst being assisted through the throat body has to pass from a wide bore nipple into a tapered section prior to the location of the primary steam nozzle, thus constraining the material and potentially causing blockages. Equally the throat body is of smaller dimension than the intake nipple and the tapered section, thus combining to create a constriction to the flow, albeit that the intention is to provide a concentration of impact and heat application for the purpose taught. The secondary or discharge nozzle fulfils a similar function to that of the primary nozzle to give a second stage impact and fluidising effect to the flowing material thus to enhance induction of the material through the system. The potential disadvantage of the *Schwarz* system is that by virtue of the convergent nature of the inlet to the unit and the constricted throat portion the free flow of fluid materials therethrough is likely to be difficult or restricted by the physical characteristics of the materials.

Canadian Patent No 833 980 to Schutte and Koerting Co is concerned with a jet pump of the type having a compressible flow in the diffusor and a supercritical ratio of suction to discharge pressures. The method and apparatus described by Schutte and Koerting are aimed at overcoming certain defined disadvantages associated with the operation of jet pumps in which supersonic velocities initially prevail in the mixture of the motive or thrust stream and the suction stream. As is explained in this prior art the change from supersonic to subsonic velocity occurs in a shock zone. In particular the problem associated with this type of pump, used for pumping gas, resides in controlling the positioning of the shock

wave which is critical in that if it moves into either the intake or the discharge zone of the diffusor, significant difficulties arise. In particular, if the shock wave moves into the convergent conical intake zone the jet pump becomes unstable and might even fail. If the shock wave moves into the divergent conical exit zone the rate of flow of the mixture of the thrust and suction streams is accelerated resulting in a reduction in efficiency. The patentees propose a method of monitoring the prevailing conditions within the diffusor and to vary the thrust stream accordingly in order to position the shock wave accurately thereby to optimise efficiency. The jet pump of this prior art is essentially a conventional steam ejector and the invention merely lies in the monitoring and control of the shock wave positioning. This jet pump is configured for gas pumping and as such would be unsuitable for pumping liquids or liquid/solids mixtures, not least because of the significant difficulties associated with achieving supersonic velocities with substantially incompressible fluids. Clearly the amount of energy that would be required to impart supersonic velocity to the mixture would be prohibitive since the performance would be poor.

USP 3 664 768 to *Mays* concerns a fluid transformer of the straight-through type for sludges and other liquid/solids materials in which again the throat area converges, in this instance in a stepwise configuration thereby giving rise to potential impaction of the solids elements of the fluids passing therethrough. It is to be noted that Mays is silent regarding the nature of the impelling fluid.

An object of the present invention is to provide a fluid mover having essentially no moving parts having an improved performance than fluid movers currently available in the absence of any constriction such as is exemplified in the prior art herein recited.

A further object of the present invention is to provide a method of moving fluid.

According to a first aspect of the present invention a fluid mover includes a hollow body provided with a straight-through passage of substantially constant cross section, an inlet at one end of the passage and an outlet at the other end of the passage for the entry and discharge respectively of a working fluid, a nozzle substantially circumscribing and opening into said passage intermediate the inlet and outlet ends thereof, an inlet communicating with the nozzle for the introduction of a transport fluid, a mixing chamber being formed within the passage downstream of the nozzle, the nozzle being so disposed and configured that in use a supersonic shock wave is created within the mixing chamber by the introduction of the transport fluid.

The transport fluid is preferably a condensable fluid and may be a gas or vapour, for example steam.

According to a second aspect of the present invention a fluid mover includes a hollow body provided with a straight-through passage of substantially constant cross section, an inlet at one end of the passage and an outlet at the other end of the passage for the entry and discharge respectively of a working fluid, a steam nozzle substantially circumscribing and opening into said passage intermediate the inlet and the outlets thereof, a steam inlet communicating with the nozzle for the introduction of steam, a mixing chamber being formed in the passage downstream of the nozzle, the nozzle being so disposed and configured that in use a supersonic shock wave is created in the mixing chamber by the introduction of steam.

The intensity of the supersonic shock wave is controllable by manipulating the various parameters prevailing within the system when operational. Accordingly the flow rate, pressure and quality, i.e. in the case of steam the dryness, of the transport fluid may be regulated to give the required intensity of shockwave. In this connection the intensity of the shockwave essentially relates to its degree of development within and across the passage and the mixing chamber. For example the shockwave may develop across the whole section or may only partially do so providing a central core that is open. The intensity of the shockwave may therefore be variable dependent upon the particular task the fluid mover has to perform. Furthermore the intensity of the shockwave may also be determined or defined by its position within or possibly without the passage or mixing chamber.

The supersonic shockwave constitutes in one aspect of its function a barrier through or across which fluid flow occurs in one direction only and in that respect may be regarded as a one-way valve, there being no designed possibility of backflow through the shockwave. Further, it is thought that the supersonic shockwave provides a self-induction mechanism whereby the transport fluid is drawn in by the very shockwave the fluid produces and accordingly is to some extent self-perpetuating when in operation.

The passage may be of any convenient cross-sectional shape suitable for the particular application of the fluid mover. The passage shape may be circular, rectilinear or any intermediate shape, for example curvilinear.

Preferably the nozzle is located as close as possible to the projected surface of the working fluid in practice and in this respect a knife edge separation between the transport fluid or steam and the working fluid stream is of advantage in order to achieve the requisite degree of

interaction. The angular orientation of the nozzle with respect to the working fluid stream is of importance and may be shallow.

In some embodiments of the present invention a series of nozzles is provided lengthwise of the passage and the angular orientation of the nozzles may vary from one to the other dependent upon the effect desired. In the case where a series of nozzles is provided the number of operational nozzles is variable.

The nozzle may be of a form to correspond with the shape of the passage and thus for example a circular passage would advantageously be provided with an annular nozzle circumscribing it.

In the case of a rectilinear passage, which may have a large width to height ratio, nozzles would be provided at least on each transverse wall, but not necessarily on the side walls, although the invention optionally contemplates a full circumscription of the passage by the nozzle irrespective of shape.

The or each nozzle may be continuous or may be discontinuous in the form of a plurality of apertures, e.g. segmental, arranged in a circumscribing pattern, that may be circular. Each aperture may be helically formed in order to give in practice a swirl to the flow of the working fluid.

The or each nozzle may be of a convergent-divergent geometry internally thereof, and in practice the nozzle is configured to give the supersonic flow of transport fluid within the passage. For a given steam condition, i.e. dryness, pressure and temperature, the nozzle is preferably configured to provide the highest velocity steam jet, the lowest exit pressure and the highest enthalpy.

For example only, and not by way of limitation, an optimum area ratio for the nozzle, namely exit area: throat area, lies in the range 1.75 and 7.5, with an included angle of less than 9°.

The or each nozzle is conveniently angled towards the flow since this occasions penetration of the working fluid and advantageously prevents premature condensation of the steam at the wall of the passage, where an adverse temperature differential prevails. The angular orientation of the nozzles is selected for optimum performance in terms of the condensation rate which is dependent inter alia on the nozzle orientation and the internal geometry of the mixing chamber. Further the angular orientation of the or each nozzle is selected to control the film condensation profile and the condensation shock wave position in accordance with the pressure and flow rates required from the fluid mover. Moreover, the creation of turbulence, governed inter alia by the angular orientation of the nozzle, is important to achieve optimum performance by dispersal of the working fluid in order to increase acceleration. This aspect is of particular import when the fluid mover is employed as a pump. In the present invention it has been found that an angular orientation for the or each nozzle may lie in the range 0 to 30°.

A series of nozzles may be provided longitudinally of the passage and in this instance the nozzles may have different angular orientations, for example decreasing from the first nozzle in a downstream direction.

The mixing chamber geometry is determined by the desired and projected output performance and to match the designed steam conditions and nozzle geometry. In this respect it will be appreciated that there is a combinatory effect as between the various geometric features and their effect on performance, namely there is interaction between the various

design and performance parameters having due regard to the defined function of the fluid mover.

At the location of the or each nozzle in the passage, the dimension of the passage is greater than either upstream or downstream thereof since this increase compensates for the additional volume of fluid introduced. However, the cross sectional area of the mixing chamber is always consonant with or greater than the cross sectional area of the passage whereby any material entering the passage meets no constriction. The cross-sectional area of the mixing chamber may vary with length and may have differing degrees of reduction along its length, i.e. the mixing chamber may taper at different angles at different points along its length. The mixing chamber tapers from the location of the or each nozzle and the taper ratio is selected such that the velocity and pressure distribution of the condensation shock wave is maintained at its optimum position. This point is found in the region of the throat of the mixing chamber, but the invention also foreshadows a different position, for example just after the throat. As heretofore indicated the intensity of the shockwave is controllable and coupled with its positioning will dictate its performance characteristics. As foreshadowed <u>supra</u> the supersonic shockwave may not extend across the whole of the cross-sectional dimension of the passage or mixing chamber and may resemble an annulus, for example it may be akin to a doughnut shape with a central relief. The regulation of the shockwave is a determinant of the performance of the fluid mover and is in turn dictated by its particular application.

The mixing chamber of the present invention may be of variable length in order to provide a control on the extent of the supersonic shock wave which dictates the point at which collapse or implosion of the steam, *i.e.* condensation and pressure drop, occurs thus affecting the performance of

the fluid mover. The length of the mixing chamber is thus chosen to provide the optimum performance regarding momentum transfer. In some expressions of the invention the length may be adjustable in situ rather than predesigned in order to provide a measure of versatility. The collapse of the steam gives rise to an implosive force which also influences the entrapped working fluid within the circumscribing steam stream to the extent that a pinching effect takes place. Accordingly the steam collapse is focused and the working fluid induced thereby is directionalised.

A cowl may be provided downstream of the outlet from the passage in order to enhance the collapse effect and to harness the pressure and to accelerate an additional volume of the working fluid stream.

The fluid mover may also be provided with an air or gas inlet nozzle provided in the passage intermediate the inlet and the outlet. The air or gas nozzle may be circumscribing, e.g. annular, and may be located upstream and/or downstream of and/or coincident with the nozzle for the transport fluid or steam. In the case where the air or gas inlet nozzle is downstream of the fluid transport nozzle a secondary mixing capability arises.

The air inlet or other inlets which may be provided in the passage, may be used for the introduction of other gases or liquids or of other additives that may for example be treatment substances for the working fluid or may be particulates in powder or pulverulent form and used to seed the working fluid. The other inlets may additionally or alternatively be employed for the introduction of further working fluid.

In a further embodiment of the present invention the fluid mover is disposed within a chamber provided with an inlet and an outlet, the inlet

diverging to a central section of constant cross section in which the fluid mover is located and the chamber converging towards the outlet thereof. In this arrangement the working fluid is induced through the fluid mover and also around it within the confines of the chamber the outlet of which is no smaller than its inlet.

The fluid mover of the present invention may also be used in heating applications where the heat in the case of steam when used as the transport fluid is employed since necessarily the working fluid will receive heat from the steam. The heat of the steam may also have advantageous effects on the physical properties of the working fluid; for example the viscosity of the working fluid may be reduced.

According to a third aspect of the present invention a method of moving a working fluid includes presenting a fluid mover to the fluid, the mover having a straight-through passage of substantially constant cross section, applying a substantially circumscribing stream of a transport fluid to the passage through an annular nozzle, generating a supersonic shock wave within the passage downstream of the nozzle, inducing flow of the working fluid through the passage from an inlet to an outlet thereof, modulating the shock wave to vary the working fluid discharge from the outlet, and causing the collapse of the transport fluid thereby to create a region of low pressure to induce flow of the working fluid through the passage.

The transport fluid is preferably a condensable fluid and may be a gas or vapour, for example steam.

According to a fourth aspect of the present invention a method of moving a working fluid includes presenting a fluid mover to the fluid, the mover

having a straight-through passage of substantially constant cross section, applying a substantially circumscribing stream of steam to the passage through an annular nozzle, generating a supersonic shock wave within the passage downstream of the nozzle, inducing flow of the working fluid through the passage from an inlet to an outlet thereof, modulating the shock wave to vary the working fluid discharge from the outlet, causing the collapse of the steam by virtue of condensation thereof to create a region of low pressure thereby to induce working fluid flow through the passage.

In carrying out the method of the present invention the creation of a shock wave is occasioned by the design of the nozzle interacting with the setting of the desired parametric conditions, for example in the case of steam as the transport fluid the pressure, the dryness or steam quality, the temperature and the flow rate to achieve the required performance of the steam nozzle.

The fluid mover of the present invention may be employed in a variety of applications ranging from marine propulsion, where the mover is submersed within a body of fluid, namely the sea or lake or other body of water, to its use as a pump or mixer or aerator. In its application to pumping a variety of working fluids may be moved and may include liquids, solids, liquids with solids in suspension, slurries, sludges and the like. It is an advantage of the straight-through passage of the mover that it can accommodate rogue material that might find its way into the passage. The velocity and pressure generated within the passage and enhanced by the collapse of the transport fluid or steam are such as to ensure rapid movement through the passage. Such an advantage is also of particular import in the use of the fluid mover as a propulsion unit in the marine field where flotsam and jetsam can be a serious problem inhibiting the smooth running of more conventional propulsion units. It

has been found that the present invention by virtue of the shock wave affords a mechanism occasioning capability for breaking up any friable or readily disintegratable rogue material that may have entered the passage, the shock wave having a disintegrating effect on the material.

By way of example, four embodiments of a fluid mover in accordance with the present invention are described below with reference to the accompanying drawings in which:

Figure 1 is a cross sectional elevation of a first embodiment;
Figure 2 is a cross sectional elevation of a second embodiment with respective end views shown;
Figure 3 is a cross sectional elevation of a third embodiment with respective end views shown; and
Figure 4 is a cross sectional elevation of a fourth embodiment with respective end views shown.

Like numerals of reference have been used for like parts throughout the specification.

Referring to Figure 1 there is shown a fluid mover 1 comprising a housing 2 defining a passage 3 providing an inlet 4 and an outlet 5, the passage 3 being of substantially constant circular cross section.

The inlet 4 is formed at the front end of a protrusion 6 extending into the housing 2 and defining exteriorly thereof a plenum 8 for the introduction of a transport fluid, the plenum 8 being provided with an inlet 10. The protrusion 6 defines internally thereof part of the passage 3. The distal end 12 of the protrusion 6 remote from the inlet 4 is tapered on its relatively outer surface at 14 and defines an annular nozzle 16 between it and a correspondingly tapered part 18 of the inner wall of the housing 2,

the nozzle 16 being in flow communication with the plenum 8. The nozzle 16 is so shaped as in use to give supersonic flow.

In operation the housing 2 in one application is disposed in a body of a working fluid (not shown), for example water, the inlet 4 being connected to a source of a transport fluid such as steam. Introduction of the steam into the fluid mover 1 through the inlet 10 and plenum 8 causes a jet of steam to issue forth through the nozzle 16. The parametric characteristics of the steam are selected whereby in use a supersonic shock wave is generated within the passage 3 downstream of the nozzle 16 in a section of the passage operating as a mixing chamber. In operation the shock wave is created in the mixing chamber and is maintained at an appropriate distance within mixing chamber. The steam jet issuing from the nozzle occasions induction of the working fluid through the passage 3 which because of its constant dimension presents no obstacle to the flow. At some point determined by the position of the standing shock wave, the steam collapses or implodes and thus condenses causing a reduction in pressure which enhances the induction of fluid through the passage 3.

Additionally it has been observed that the collapse of the steam, which is part of the mechanism by which the invention functions, does not give rise to a tell-tale wake and therefore the physical fluid signature of the fluid mover is thus of low level.

Figure 2 shows a second embodiment similar to that illustrated in Figure 1 save that an air inlet 30 and plenum 32 are provided in the housing 2, together with a further annular nozzle 34 formed at a location coincident with that of the nozzle 16. In this instance in use air is introduced to the passage 3 to aerate the flow whereby a three-phase condition is realised

constituted by the liquid phase of the body of water, the steam and the air.

The use of air may assist in the suppression of cavitation thus reducing physical deterioration of the housing. In this connection the suppression of cavitation has the beneficial effect of reducing noise levels and accordingly the sonic signature of the fluid mover is thus diminished. This attribute in practice would have benefits where the mover is to be used in its marine propulsion application, particularly for military usage, where running as silently as possible is advantageous.

The air nozzle 34 or another nozzle or nozzles may alternatively form the inlet for other fluids for use in mixing or treatment purposes. For example, a further air nozzle may be provided in the passage to provide aeration of the working fluid if necessary.

Referring now to Figure 3 the fluid mover of Figure 1 is provided with a frusto-conical cowl 40 adjacent the outlet 5 of the passage 3. Its disposition at this location allows a further concentration of the induction effect by virtue of the working fluid being drawn in not only through the inlet 4 but also through the annulus 42 formed between the outlet 5 and the internal wall of the cowl 40. A venturi effect is produced and thus affords a further acceleration of the flow through the combination of the housing and the cowl and thus the thrust is enhanced. The position of the cowl may be varied in order to give the desired effect.

With reference to Figure 4, the embodiment of Figure 1 is disposed centrally within a casing 50 having a diverging inlet portion 52 having an inlet opening 54, a central portion 56 of constant cross section, leading to a converging outlet portion 58 having an outlet opening 60. In use the inlet and outlet openings 54 and 60 are in flow communication with a

body of a working fluid either therewithin or connected to a conduit. In operation the working fluid is drawn through the casing 50 with flow being induced around the housing 2 and also through the passage 3 of the mover which is of similar design to that shown in Figure 1. The convergent portion 58 of the casing provides a means of enhancing the accelerative effect of the fluid mover and thus improves the thrust of the fluid flow.

EXAMPLE

By way of example only, we have designed a fluid mover having a central passage bore of 47mm for use at 5 bar gauge of steam with a dryness of 99%, the annular nozzle having an area ratio of 1.9 with an included angle of 5.7° and a throat gap of 1.34 mm. The angle at which the nozzle is orientated in relation to the axis of the flow passage and that of the mixing chamber is 24°. The mixing chamber has a double taper starting at 8° and reducing to 3° included angle at 60% of its length, the length to diameter ratio being 2.13. It has been found that this configuration provides a fluid mover giving greater performance than conventional equivalents.

The present invention provides the means whereby the generation of a supersonic shock wave within the fluid mover and its extension therefrom with the attendant condensation of the transport fluid, namely steam, the thrust afforded is enhanced by virtue of the momentum transfer from the steam to the working fluid giving it added acceleration. The action of the supersonic shock wave is controllable by varying the geometry of the fluid mover and the parametric conditions of the transport fluid.

The present invention differs from the prior art as embodied particularly in Canadian Patent No 833 980 in that the positioning of the shock wave is not critical; although its positioning in the mixing chamber, equivalent

to the conical inlet zone of Schutte and Koerting, is advantageous it may be generated at any desired position with subsonic velocities prevailing both upstream and downstream, supersonic velocity only occurring at the shock wave itself. Although the geometry of the present invention is of importance it is not dependent upon the use of the conventional 'venturi' configuration of a convergent inlet zone, a throat and a divergent outlet zone which characterises and is the essential geometry of the Schutte and Koerting jet pump. The Schutte and Koerting jet pump is specifically directed at the precise positioning of the shock wave to prevent spasmodic or erratic flow conditions.

In the present invention the supersonic velocity and the generation of the shock wave creates an accelerative effect which is of considerable advantage. This mode of operation is accordingly in sharp contrast to the Schutte and Koerting approach which teaches in precisely the opposite direction. It is to be noted that Schutte and Koerting regard such an accelerative effect to be deleterious in terms of a reduction in efficiency.

Indeed the Schutte and Koerting approach predicates the existence of a spasmodic flow by virtue of the hunting of the shock wave within the diffusor and the objective is to smooth out the flow. In contradistinction the present invention does not rely on precision location of the shock wave within the bounds of the apparatus in order for it to operate satisfactorily. Furthermore it would appear that the prior art shock wave would in practice extend across the whole of the diffusor section, and since the pumped fluid is gas this full section shock wave would be generated. As foreshadowed *supra* the shock wave of the present invention may not extend across the whole of the chamber cross section and may be constituted in a doughnut form with a central opening. Such variation in shock wave contour is entirely acceptable in the present invention and in certain applications may be particularly advantageous in

terms of the shock wave becoming a threshold of momentum transfer at the point of steam condensation which itself creates a high pressure gradient, the implosive and inductive effect thereof providing the intended acceleration of the fluids.

The present invention is thus versatile in contrast with Schutte and Koerting in that as aforesaid the shock wave positioning is not critical, thus enabling a broader range of operating parameters and indeed applications particularly with regard to the types of fluid throughput.

It is also the case that at the point of shock wave generation a disintegrating effect is realised and for certain applications, for example those in which fluid/solids mixtures are to be pumped this effect is advantageous in facilitating and smoothing flow patterns and indeed in enhancing the efficiency of the pumping mechanism. Additionally in certain applications disintegration of the solids element of the mixtures is an objective and of prime consideration, and the shock wave front effectively breaks down the solids into discrete pieces. The advantage of the present invention in this respect is that it affords a duality of function in terms of smoothing flow and of fulfilling a process application requirement.

As has been indicated above, the present invention possesses a number of advantages in its operational mode and in the various applications to which it is relevant. For example the 'straight-through' nature of the fluid mover having a substantially constant cross section means that not only will fluids containing solids be easily handleable but also any rogue material will be swept through the mover without impedance. The suppression of cavitation effected by aeration of the working fluid which also reduces surface friction losses, also diminishes its sonic signature

and accordingly benefits accrue in terms of the application of the invention in the field of marine propulsion particularly in the military arena. The suppression of cavitation also has benefits in obviating the cause its deleterious physical effects, such as pitting.

In the case where only two phases are present, the steam collapse which gives the momentum transfer to the working fluid only gives a transient wake and accordingly the physical flow signature of the mover is small and short-lived. Again benefits are derived from such a mechanism.

The present invention thus affords wide applicability with improved performance over the prior art proposals in the field of fluid movers.

It is to be understood that the expression 'aeration' as used herein is intended to cover the introduction of air or other gas into the working fluid.

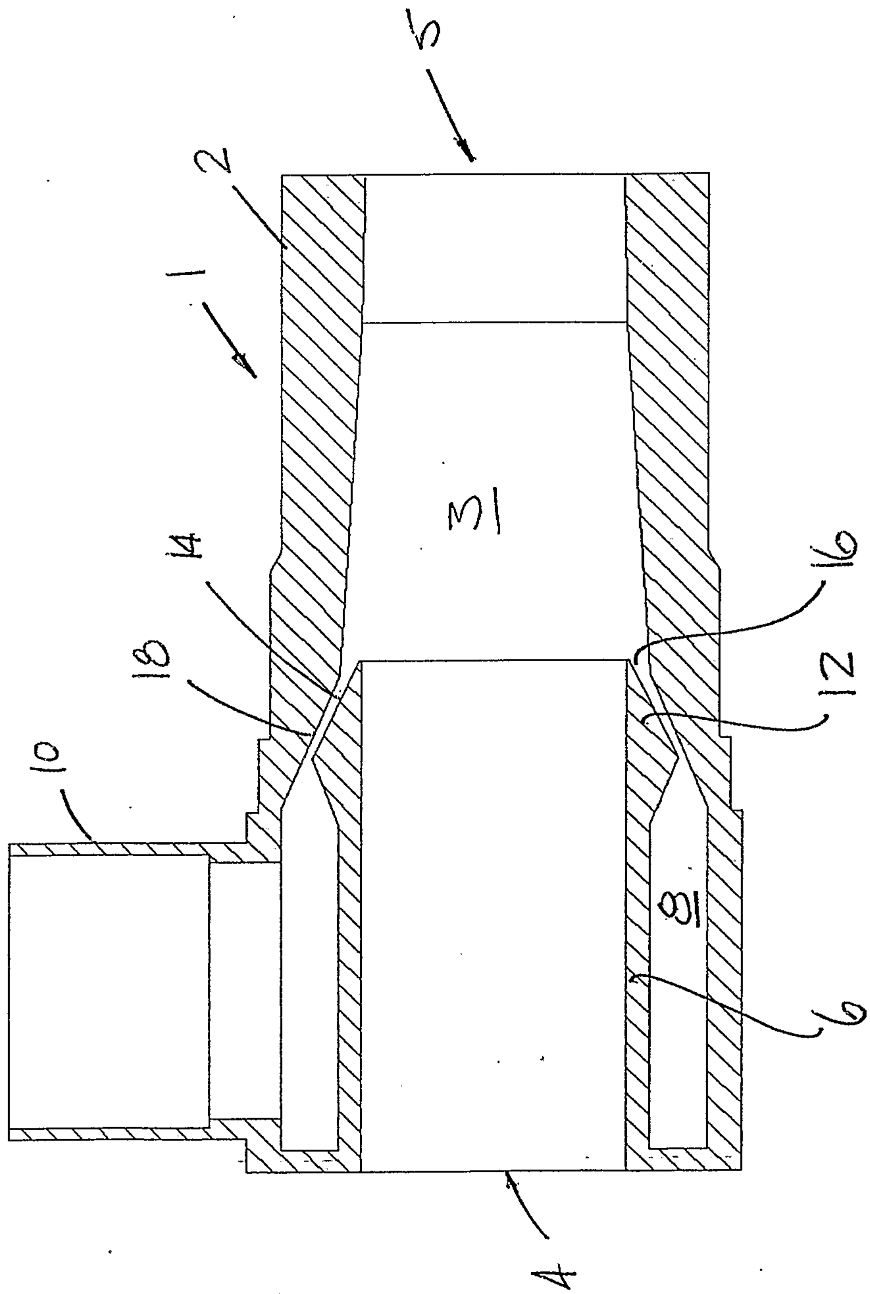

FIGURE 1

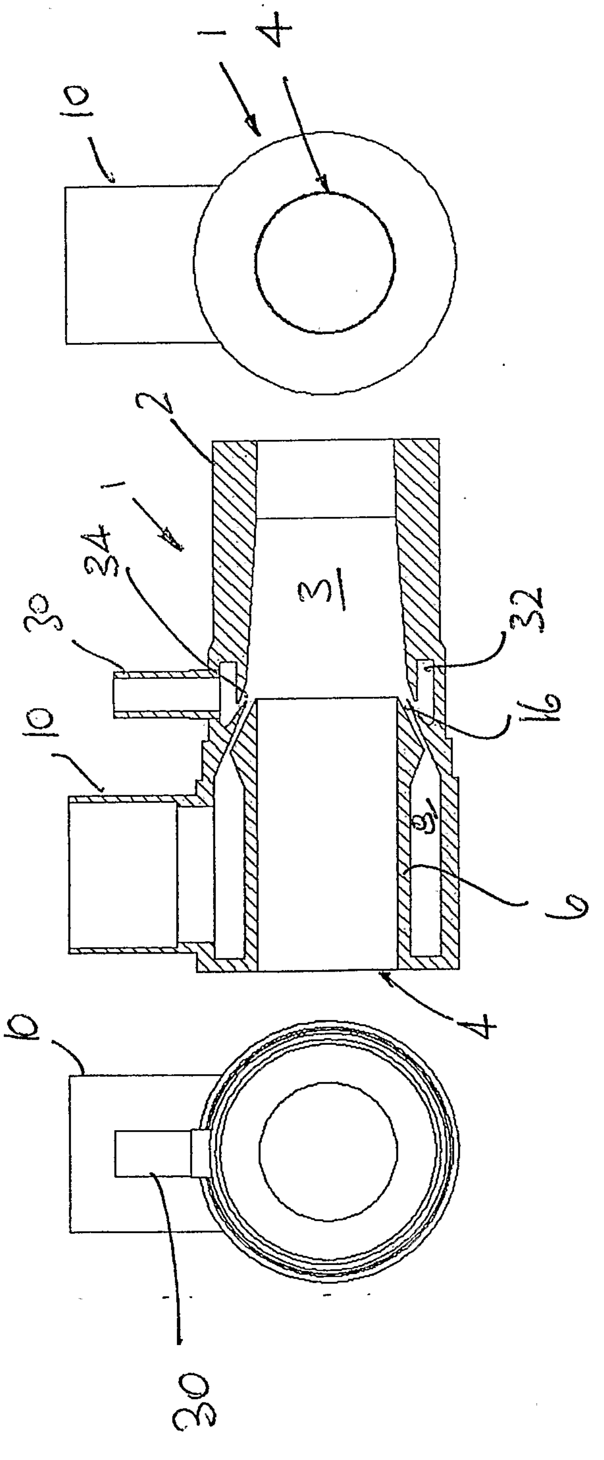

FIGURE 2

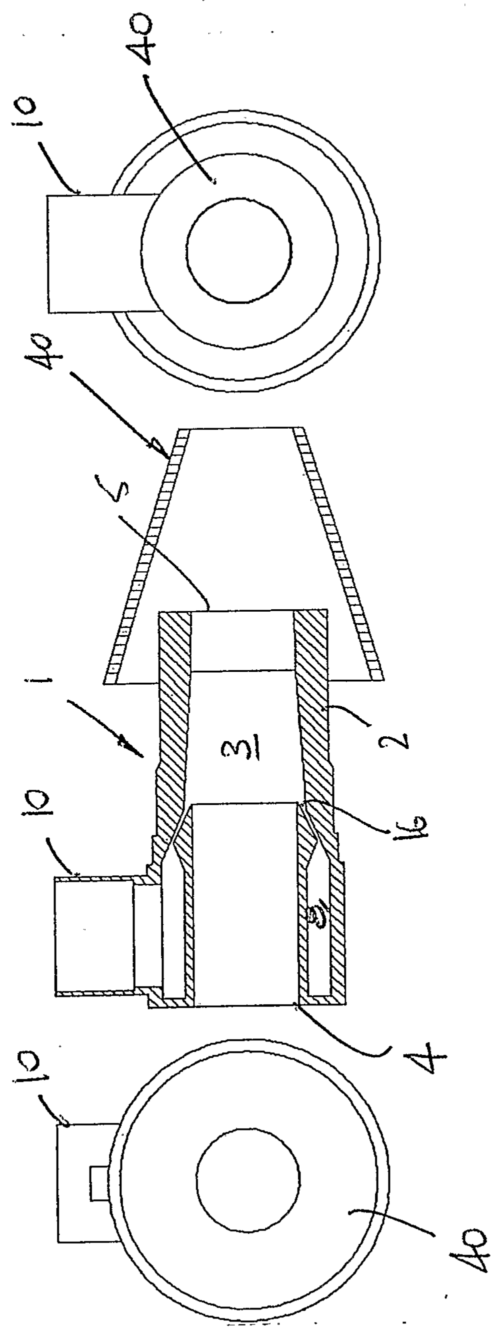

FIGURE 3

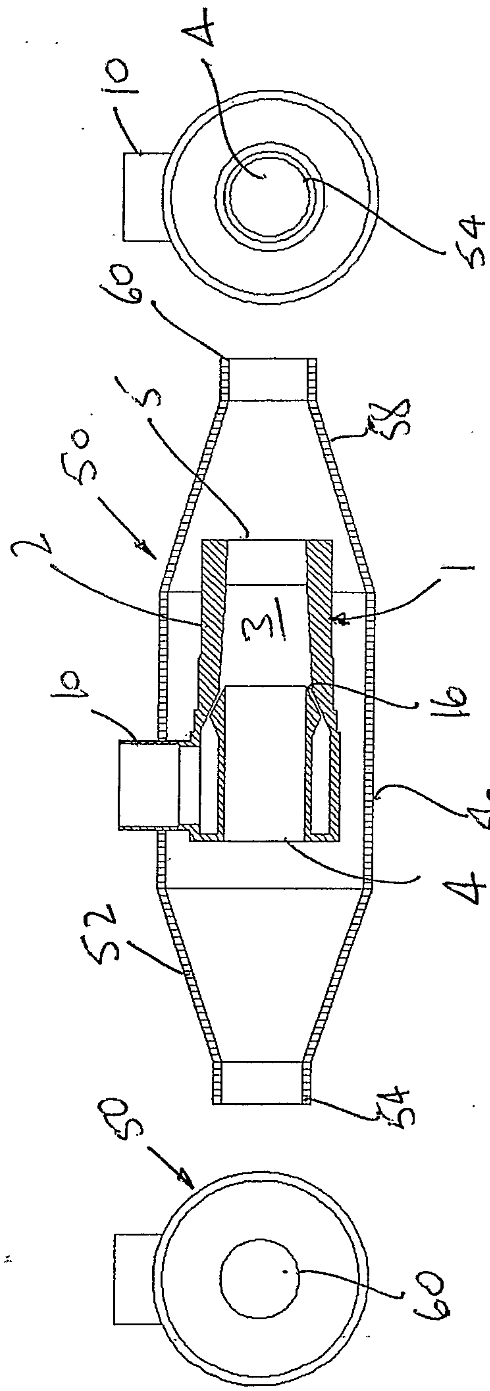

FIGURE 4

PCT Application
GB0304400